CHAPTER 11

INTRODUCTION TO A SHIPBOARD WEAPONS CONTROL SYSTEM

This chapter will give you an overview of a shipboard gun and missile weapon system. The treatment is brief for several reasons. First, to describe the physical features and functioning of components of a weapon system in detail would require several volumes. Second, security requires that we describe the functions of certain equipments in very general terms. In some cases values of range, target height, target speed, and other characteristics of the target and equipment have been left out. But this chapter will provide you with the background you will need to understand the many weapons systems now in the fleet.

WEAPONS SYSTEM CONCEPT

The effective use of any weapon requires that a destructive device (usually containing an explosive) be delivered to a target—usually a moving target. To deliver the weapon accurately, we must know the location of the target, as well as its velocity and direction of motion. Many targets now travel faster than sound, and must therefore be engaged at great distances. Against such targets, a weapon is most effective when it is used as part of a weapon system. A weapon system is the combination of a weapon (or multiple weapons) and the equipment used to bring their destructive power against an enemy.

A weapons system includes:

1. Units that detect, locate, and identify the target.
2. Units that direct or aim a delivery unit.
3. Units that deliver or initiate delivery of the weapon to the target.
4. Units that will destroy the target when in contact with it or near it. These units are usually termed weapons.

DETECTING UNITS

The first steps in using a weapon system to solve the fire control problem are to detect, locate, and identify the target. Initial contact with a surface or air target may be visual, or it may be made by radar. It is difficult to detect a target visually at long range, or even at short range when visibility is poor. For that reason, targets are usually detected by search radar. Search radars, as you know, keep a large volume of space around your ship under continuous watch. They give the ship accurate information about the target's position, even when the target is hidden by fog or darkness. To determine a target's position we must know its range, its direction from the ship, and, for an air target, its elevation. Radar gives all three of these coordinates. (Radar has certain disadvantages, too. For example, it can be detected by an enemy at about 1.5 times the range at which it can pick up an enemy target.)

Optical devices are used as a source of information on slow-moving targets at relatively short range. They are useless against missiles or jet aircraft, which must be engaged while they are still beyond the range of optical instruments.

After we have detected and located a target, we must identify it. How can we identify a target that may be several hundred miles from out ship? The answer lies in a device called IFF (Identification, Friend or Foe). Radar alone cannot tell the difference between a friendly or enemy target. But the IFF equipment can challenge an unidentified target, and determine from the answer whether the target is friendly. The equipment consists of two major units—the challenging unit which asks the question, friend or foe, and the transponder which answers the question. IFF equipment is used in conjunction with search radar, and sometimes fire control

radar. Briefly, this is how it works. To challenge a target you press a switch attached to the radar. The IFF transmitter will then send out a pulse of low power radio energy toward the target. If the target is friendly it will carry a transponder, which consists of a receiver and a transmitter. When the receiver picks up a challenge, it causes the transmitter to send out an answering pulse or pulses. The answer is usually a coded message. It is picked up by the challenging unit's receiver and sent to the indicator of the search radar.

CONTROL UNITS

Control units in a weapon system develop, compute, relay, and introduce data into a delivery unit, a weapon, or both. They direct, control, or guide the weapon (destructive device) to the target, and cause it to function in the desired way. These units form the heart of the weapon system.

Types of Control Units

The devices that perform the control functions include: DATA TRANSMISSION SYSTEMS that send target position information developed by the detecting units to the rest of the weapon system, and convey other data among the components of the weapon system. Examples are synchro, resolver, and potentiometer circuits.

COMPUTER DEVICES are used to process the input data from the detecting units and other sources, and put out the aiming and program instructions that cause the weapon to reach its target. Examples are range-keepers and computers.

DISPLAY UNITS display information at various locations on the ship. These are generally electronic, electromechanical, or optical devices.

DIRECTING DEVICES are those which, with the aid of detecting devices, establish target location. Directing devices can also function to directly or indirectly control missile flight. Examples are gun and missile directors, and radar sets.

REFERENCE DEVICES are those such as stable elements, which establish reference planes and lines to stabilize lines of fire, lines of sight, and other references. These units usually are gyroscopically controlled.

DELIVERY UNITS

Broadly speaking, delivery units launch or project destructive units toward the target. Examples are guns, missile and rocket launchers, torpedo tubes, and depth charge projectors. Don't think of these devices as weapons. The term WEAPON is properly applied to the destructive unit that is launched or projected. Thus a guided missile launcher is not, strictly speaking, a weapon; the missile itself is the weapon.

To be effectively used against their targets, all weapons must either be aimed at their targets or be programmed during flight; they may require both aiming and programming. Programming is the process of setting automatic equipment to perform operations in a predetermined step-by-step manner. Aiming and programming are done at or before the time of launching, either by or through the delivery device. This function is characteristic of all delivery devices, even the simplest. Aiming the destructive device (weapon) at the target may be done simply by positioning the delivery device (a gun barrel or launcher guide arm, for example). Or it may be done without aiming the delivery device, by placing program instructions in the weapon. Some missiles are programmed to start searching for the target after the launching phase is over. Examples of other programmed functions that could be performed in the weapon are ignition of propulsion units and arming of the warhead after a designated number of seconds in flight.

Types of Delivery Devices

Two representative types of delivery devices are guns and missile launchers.

GUNS provide all the propulsion energy to their projectiles, and direct (aim) the projectiles by positioning the gun barrels.

MISSILE LAUNCHERS retain and position missiles during the initial part of the launching phase, and, by means of attachments to the launcher, feed steering, vertical reference, and program information into the missile up to the instant of launch.

DESTRUCTIVE UNIT

The end purpose of detection units, delivery units, and control units is to cause the destruction unit to intercept or pass near the target.

It is then the function of the destruction unit to destroy or inflict maximum damage on the target.

Basic Weapon Components

All weapons have these components:

1. A CONTAINER or BODY which houses the internal components. The body may have such other functions as piercing armor, breaking up into high velocity fragments when the weapon or projectile explodes, or improving the weapon's ballistic characteristics by means of fins or streamlining.

2. A DETONATING DEVICE (called a fuze, an exploder, a detonator, etc.) which initiates explosion at the proper time, and includes safety devices to prevent premature explosion.

3. A PAYLOAD which is the "reason for being" of the weapon or projectile. The payload usually consists of high explosive or nuclear material.

Weapons of some types have their own propulsion systems. The outstanding examples are guided missiles, torpedoes, and rockets. With the exception of rockets, weapons that have a propulsion system also contain guidance and control systems.

REPRESENTATIVE WEAPONS SYSTEM

Figure 11-1 depicts the major components of a representative weapons system. The equipments making up each of the four categories of functional components are enclosed in separate blocks. We will introduce and discuss the four groups of equipments in the order in which they operate to solve the fire control problem.

TARGET DETECTION, LOCATION, AND IDENTIFICATION

The first contact with an airborne target is usually made by air search radar. These radars are designed to keep a large aerial volume under nearly continuous observation. Jet aircraft travel at high speed, and may launch guided missiles against our ships from a great distance. This requires that our radar search be carried out to long range. To cover the necessary area, search radar uses a wide beam. In addition, most search radar antennas rotate as they search. Targets show up on the radar's target display indicators as alternately fading and brightening spots. It is difficult to determine target range, course, and speed from these spots. All of these factors limit the accuracy with which search radar can provide information about target position. For target information of the required accuracy, we must depend on fire control radars.

After the search radar has detected a target and determined its approximate location, the next step in the development of the fire control problem is to identify the target. The problem of recognizing and identifying a friend or foe is as old as warfare. Passwords, flag hoist signals, and even the uniforms we wear are identification devices that have been developed through the years.

In modern warfare the identification problem is urgent. Radar systems present targets in the form of spots or spikes (called echoes) on a radar screen; but friendly and enemy targets look alike on the screen. Furthermore, high speed planes and guided missiles give us very little time to slove this problem. And when friendly fighter aircraft pursue enemy planes to within weapon range of our ships, the identification problem is acute.

As we said before, IFF is the device we use to determine whether the target is a friend or foe. Although search radar and IFF are not part of the fire control system, they are components of your ship's weapons system.

Before we leave the subject of the major equipments that fall in the category of detection, location, and identification units, we want to emphasize that solution of the fundamental fire control problem begins with detection of a target. The next step is to locate it. And the final step in this initial phase is to identify it as friend or foe. These three steps combine to form the first phase (Phase 1) in the functioning of a weapon system. At this point you should begin to see that you must think in terms of a complete weapons system in order to understand the functioning of each individual component in the system.

Now let's consider the CONTROL UNITS in group (2) (fig 11-1).

THE WEAPON CONTROL SYSTEM

Once the air search radar detects and roughly locates the target, and the IFF equipment has determined whether it is a friend or foe, the target information from these sources

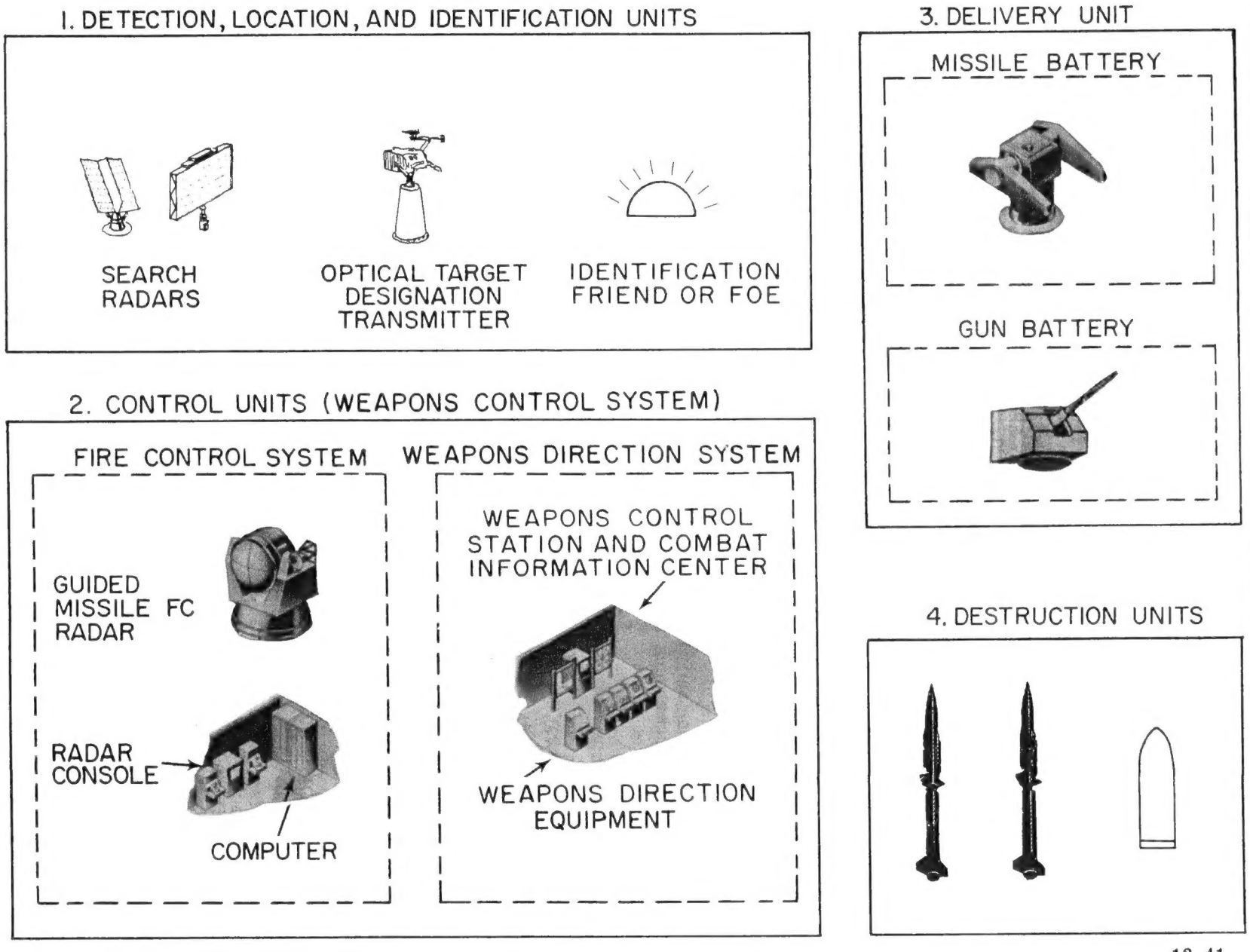

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Figure 11-1. —Makeup of a weapon control system.

is sent to the equipments that we have called control units. These units include fire control radars, directors, computers, weapon direction equipment, stable elements, and many other mechanical, electrical, and electronic instruments.

Traditionally, the systems of equipment used for the control of a particular battery of guns, torpedoes, or other weapons, have been known as fire control systems. But the complexity of guided missiles has required the introduction of new fire control instruments, and new terms to describe them. In the following paragraphs we will define some of these terms.

All the units that are enclosed by the solid line in block (2) of figure 11-1 form a WEAPON CONTROL SYSTEM. A weapon control system is defined as a group of interconnected and interrelated equipments that are used to control the delivery of effective fire on selected targets. The system is composed of a WEAPON DIRECTION SYSTEM and one or more FIRE CONTROL SYSTEMS.

Figure 11-1. —Makeup of a weapon control system.

Weapon Direction System

A WEAPONS SYSTEM begins to function as soon as a target is detected. However, a FIRE CONTROL SYSTEM begins its functioning by determining the future target position with all possible precision, so that a line of fire can be established. Before a fire control system can establish a line of fire, certain preliminary processes must take place within the weapon system. These processes are:

1. Detection of a target by search radar or other devices
2. Identification of the target by IFF or other devices
3. Evaluation of the target
4. Designation of the target to a fire control system
5. Acquisition of the target by a fire control system

The target position and identification information obtained during the first two processes is sent to the CIC (Combat Information Center) and to the WCS (Weapon Control Station). These two organizations of equipment and personnel may be in the same compartment or in separate locations. Here, we will consider them to be in the same compartment. This compartment also contains the units that make up part of the Weapon Direction System (WDS). This particular group of equipments is known collectively as WEAPON DIRECTION EQUIPMENT (WDE). The WDE, and units that support its function, make up the Weapon Direction System of a ship.

The purpose of the WDS is to perform those functions that are required during three phases of a tactical situation. During the first phase, the equipment provides electronic means for the display of targets detected by search radars, and it provides devices for selecting and initially tracking the targets that show up on the displays. These displays are similar to the PPIs (Plan Position Indicator). Targets show up as bright pips or dots on the face of the scope.

As the tactical situation develops, and the targets get closer, the system provides means for evaluating the situation and assigning a fire control system or systems to acquire and track designated targets. This is the second phase in the tactical situation. The third and last phase requires that weapons be assigned by the WDS to the fire control system that is tracking the target. Before weapons are assigned, the tactical situation must be reevaluated.

So far in this discussion, we have introduced three new terms: evaluation, designation, and acquisition.

Target EVALUATION is concerned with these questions:

1. What does the target intend to do? Is it going to pass close to the ship for observing, or is it going to launch an attack?
2. How threatening is the target to the ship's safety? If its obvious intent is to attack, how much time does the ship have to launch a counterattack? What weapons should the ship use to repulse the target?
3. What kind of attack is the target capable of launching? If the target carries missiles, the ship must launch weapons that will reach the target before it can launch its missiles.

There are other factors involved in evaluating a tactical situation, but these sample questions should give you some idea of what the term "evaluate" means. More examples will turn up later in this chapter.

The equipment in the weapon direction system presents a complete visual picture of the tactical situation. It displays all the targets that have been detected by the search radars. Each target must be evaluated with respect to the overall defense picture. Decisions are made to bring the ship's weapons to bear on

the most threatening targets. These selected targets must be assigned to the appropriate fire control systems. The assignment process includes two functions—designation and acquisition.

DESIGNATION is the step taken to assign the tracking element (director's radar or optical equipment) of a fire control system to a particular target. On the basis of target evaluation and the availability of fire control systems (some of which may be disabled, or busy with other targets), a decision is made to assign a fire control system to the target. This is usually done by pressing a button to activate circuitry that transmits target position information from the weapon direction system to the antenna positioning circuits of a radar set, or the power drives of a director. These units automatically move the radar antenna to the designated position. If the designation is inaccurate, the director must search for the target.

The searching process may last for a second or longer, depending on the accuracy of the designation information and other factors. Once the director has found the target and starts to track, it can be said that it has acquired the target.

ACQUISITION by the tracking device is the process of accepting a designation, acquiring the target, and starting to track it. A target is acquired when the radar has "gated" it, or the crosshairs in the director sights are on it.

In the preceding discussion we indicated that the WDS was further subdivided into the weapons direction equipment, and other equipment related to the overall function of the weapons direction system. In the following articles we shall take up the units that make up the weapons direction system.

REPRESENTATIVE WEAPONS DIRECTION EQUIPMENT

The weapon direction equipment (WDE) includes displays and controls for the evaluation of target data, and for the selection and engagement of targets so as to ensure the most effective use of the gun and missile batteries. A typical WDE conists of one or more TARGET SELECTION and TRACKING consoles, a DIRECTOR ASSIGNMENT console, a WEAPON assignment console, and the necessary cabinets to house power supplies and computer units.

Target Selection and Tracking Console

Figure 11-2 shows a representative target selection and tracking console. Regardless of the mark or modification, they all have the same general function. The console is used for

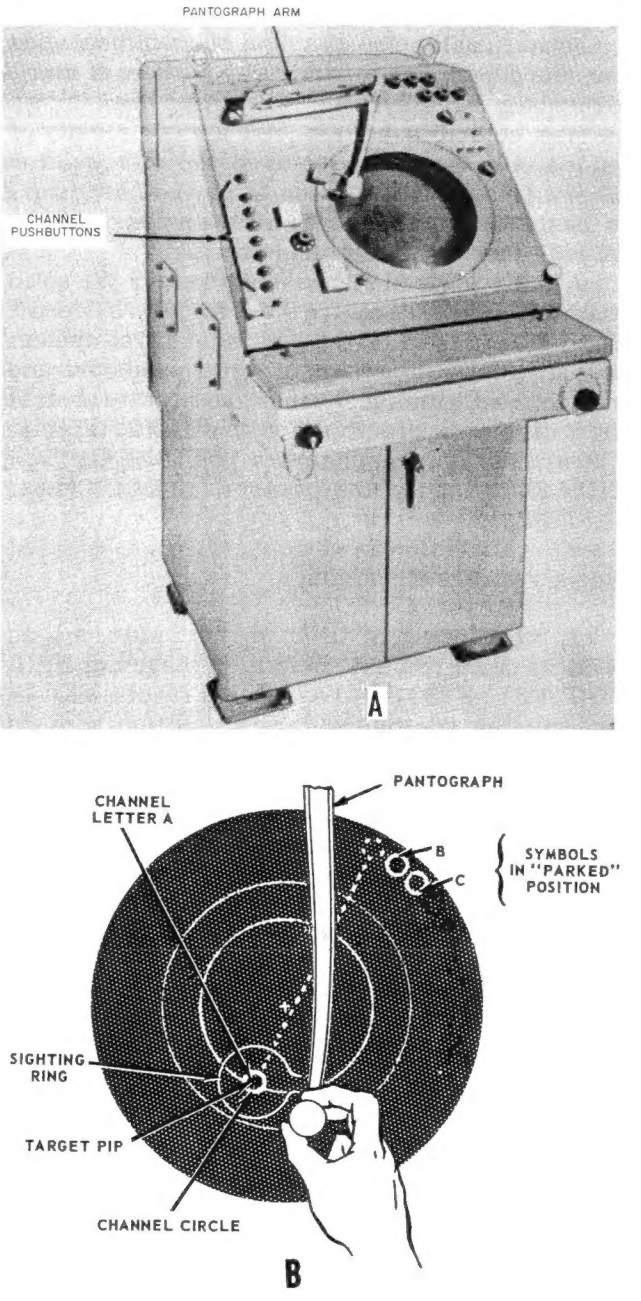

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Figure 11-2.—A. Representative target selection and tracking console. B. Scope display.

selecting and tracking targets detected by search radars. The principal indicator is a PPI that displays the true bearing and slant range of targets picked up by a selected search radar. The primary controls are a pantograph arm for selecting and tracking targets, and pushbuttons for assigning targets to tracking channels. Other controls are provided for selecting various search radars for the PPI display, for selecting the range scale, and for inserting target position and height data into the tracking channels.

Targets are displayed on the scope as radar video (pips). To select a target and assign it to a tracking channel, you position the pantograph sighting ring over the target pip and then press a channel button. Pressing the button gains electrical access to that channel, and simultaneously causes an identifying channel letter to appear next to the target pip. Successive corrections of pantograph position develop target course and speed in the tracking channels.

Director Assignment Console

The primary purpose of this console is to provide the information display and controls required to assign fire control systems to the targets being tracked by the target selection and tracking console operator, when it is determined that a specific target or targets should be engaged. Figure 11-3 shows the panel layout of the director assignment console for our basic WDE. Two plots are provided on the face of the console—a plan plot on the left, and a multipurpose plot on the right.

The plan plot shows three range rings, and indicates true bearing with north at the top. Each target being tracked by the target selection and tracking console appears on the display as a letter, corresponding to the tracking channel from which it originates. The figure shows that tracking channels A, B, and C are tracking three separate targets. The straight line associated with target A indicates the course of this target. The number 1 indicates the position of the director in the fire control system. If the weapon control system had more than one fire control system, these additional systems would have associated numerals. A ship's heading marker, and radial clearance lines on either side of it, are presented electronically and rotate when the ship changes course. The sector between the two clearance lines indicates the region into which we may not launch missiles because of danger of striking the ship's superstructure.

The multipurpose plot is used primarily for making time comparisons. These comparisons help the operator to decide which of several targets to designate to a director, and to plan the future handling of targets that cannot be assigned immediately. Once the director acquires the target and begins to track it, the fire control system is busy. During this time the operator, with the aid of the information displayed on the plot, can decide which target is next in line for assignment.

The multipurpose plot also indicates the speed and height of targets in the tracking channels. As you can see in figure 11-3, it is divided into three vertical lines—each line representing a tracking channel. All changes in indications take place vertically, and you can read the values indicated as you would read a thermometer.

The vertical lines show, for each target, the time within which the radar set must be assigned and a missile fired in order to intercept the target before it can reach its Estimated Weapon Release Range (EWRR). The EWRR will vary depending on the type of payload the enemy is carrying and on how accurate you guess what the payload is. For example, if you guess that the target's payload is an air-to-surface beam-rider missile, the EWRR might be on the order of 25,000 yards. At the left of the plot you can read how much time you have to assign the target, solve the problem, and load and fire a missile salvo, to intercept the target before it can release its missiles. This points up the need for quick evaluation. In conjunction with the plan plot, the multipurpose plot provides the necessary information to speed up this process. It relieves the operator of the necessity of remembering how much average time each component in the weapon system requires to perform its function under varying conditions.

The scale used to measure assignment time is also used with the height line. The height line is a short horizontal bar which moves up and down the vertical channel line as target altitude changes (fig 11-3). In this case the number (not shown in the figure) represents thousands of feet. To the right of the display is a target speed scale (marked knots) which is used in conjunction with the speed circle. The speed circle rides up and down to indicate target speed.

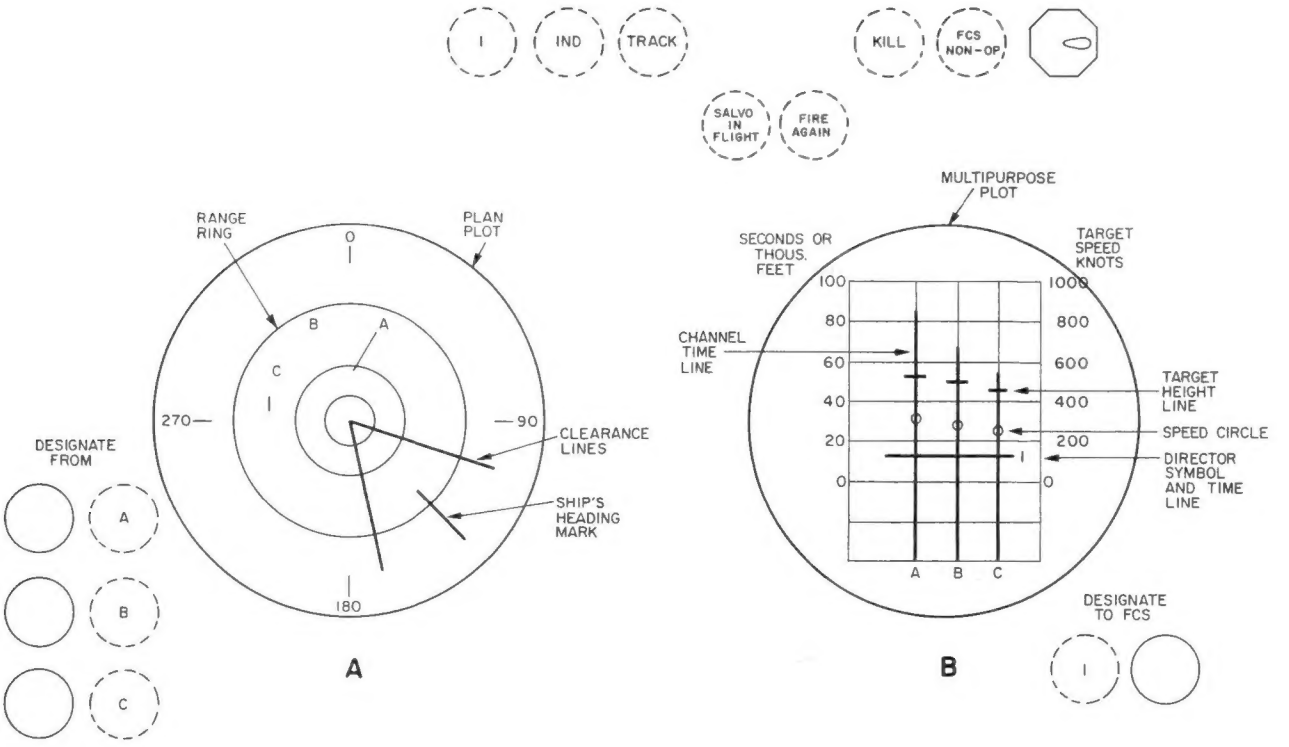

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Figure 11-3.—Director assignment console display.

The long horizontal line shown in this plot represents busy time for the fire control system. When the system is not acquiring or tracking, the time line and director symbol number rest at zero time. But when the director is assigned a target, the time line and symbol move up to indicate the time during which the director will be busy with that target; they slowly move down as time elapses. After a missile salvo is launched, the line and symbol continue to move downward until they reach zero. The missile should have intercepted the target, and the fire control system is free to be assigned a new target.

Above the two display plots is a field of lamps relating to the gun and missile fire control system. The lamp with the numeral 1 in it is called the BUSY lamp. (If our weapon control system had more than one fire control system, each of them would be represented by a different lamp and number.) The BUSY lamp is lighted whenever the director is assigned the target. The IND lamp is lighted when the director is operating INDependently of the weapon direction equipment. The TRACK lamp indicates that the assigned target is gated and is being tracked. The KILL lamp lights when a target has been destroyed. The observation of the kill is usually visual.

The FCS NON-OP lamp indicates that some part of the fire control systems is not in operation. When missiles are launched, the SALVO-IN-FLIGHT lamp lights. If another salvo is ordered to be fired, the FIRE-AGAIN lamp lights to indicate that this order has been sent to the weapon assignment console, but that the salvo has not yet been fired.

The pushbuttons at the left labelled DESIGNATE FROM, and the pushbutton at the right labelled DESIGNATE TO FCS, are used in making assignments of a director to one of the three tracking channels. The operator makes

the assignments by simultaneously pressing the selected "designate from" button and the "designate to FSC" button until both lights function. This process connects the director to the selected tracking channel and slews the director automatically onto the target. At this time the repeat-back symbol, (numeral representing the FCS), moves until it is superimposed on the track channel symbol. This indicates to the director assignment console operator that the system is tracking the proper target.

Weapon Assignment Console

The Weapon Assignment Console is the connecting link between the fire control system and the weapon launcher. It displays data from the fire control system, giving the target's present and predicted intercept positions, and information from the computer indicating whether or not missile intercept is possible. It also has a summary display of launcher information.

The missile firing key is located on the weapon assignment console. Decision of whether or not to fire is made from this station.

The console has a PPI display showing a horizontal plot and true bearing, with own ship's position in the center. Around this plot is a fixed bearing ring. Radial lines from the center to the edge of the plot, generated electronically, indicate launcher unclear areas caused by ship's heading. These lines rotate with changes in ship's heading. This display is similar to the plan plot of the director assignment console.

The other indications on the cathode-ray tube display appear only while the fire control system is tracking a target. These indications are:

1. An "X" indicating target present position

2. A small circle indicating target future position at the predicted point of intercept

3. A large circle about the center, which indicates the maximum range the missile can reach at the target's predicted altitude at intercept

4. A thermometer-type display at the left-hand edge of the plot, giving the target's predicted altitude at intercept (H)

REPRESENTATIVE MISSILE FIRE CONTROL SYSTEM

In this section we will discuss the equipments that make up the fire control system of a typical guided missile ship. Look again at figure 11-1. We have assumed that the fire control system shown is capable of controlling gun and missile batteries at the same time. This is a valid assumption, because there are systems with this capability in the fleet. But for now we will separate the capabilities and consider the fire control system a missile system. The fire control computer calculates the prediction angle and uses it as an offset to the line of sight to establish the line of fire and to produce weapon orders. The orders are transmitted to the missile launcher to position it in the line of fire.

Thus the primary basic functions of the fire control system are: to acquire and track targets; to develop launcher and missile orders; to guide missiles to the target; and in some instances to detonate the missile's warhead.

Secondary functions of the system are to provide target information such as target speed, target course, range to the target, and system and weapon status information to the display units of the weapon direction system. This information is used to evaluate the tactical situation and to aid in the fire control system and weapon assignment.

The Director or Radar Set

The director or radar set can search for, detect, acquire, and track a target; and it can "capture" and guide a missile. Let's stop and consider the terms "director" and "radar set." A director may contain a radar and/or optics for tracking and ranging, and it is usually manned. A missile director has no optical tracking device or rangefinder but relies on its radar set for tracking. It is not manned in the sense that a man is located inside the antenna supporting structure. True, there is an operator in the radar control room; but his primary function is to monitor the equipment. In the rest of this discussion we will use the term "radar set," rather than director, because that name is more descriptive of the function of a missile director.

The radar set described here, and illustrated in figure 11-1, is an automatic target tracking and missile guidance radar. It normally receives target designation signals from the weapon direction equipment, via the fire control computer. The designation signals position the radar set at the designated range, bearing, and elevation. If the radar set does not acquire the target immediately the fire control computer originates a search program for the radar set to seek out the target. If the ship has more than one fire control system, designation between systems is possible. Designation from another fire control system, called "Inter-director Designation" or "IDD", is accurate and a search program is not needed. Therefore IDD does not go to the computer but through the fire control switchboard to the radar set.

When the radar set acquires the target in range, bearing, and elevation the radar set locks on the target and starts to track it. Tracking circuits within the radar set automatically keep its tracking beam on the target. Target position is continuously transmitted to the computer. The computer and the radar set working together solve for the target's rate of movement about the ship by calculations based on the line of sight movements.

The radar not only tracks the target, but also transmits radar beams to control the missile and guide it to the target. In the case of the beam-rider missile the radar set will transmit simultaneously, on a common nutation axis, three distinct beams—the tracking, capture, and guidance beams. A narrow tracking beam first acquires and tracks the target. The wideangle beam captures the missile after launch, and holds it until it enters the narrow guidance beam that guides it to the target.

Where a semiactive homing missile is used, the radar set will transmit simultaneously, on a common nutation axis, a tracking beam, and an illuminating beam. After the missile is launched it will lock on to the illuminating radar's energy reflected from the target, and home on it. If a missile whose guidance is a combination of beam-rider and semiactive homing is launched, the radar set will transmit a tracking beam and a beam-riding guidance beam and later switch on an illumination beam.

The radar set consists of two major groups of equipment: an antenna group, and a power control group. The antenna group, which is located abovedeck, consists of a pedestal upon which is mounted the antenna and the necessary electrical and mechanical components required to stabilize and position the antenna. Housed inside the mechanical structure of the antenna group are the transmitting, receiving, and associated microwave circuits. Here, too, are located the gyroscopes that space-stabilize the antenna, and thus the radar beams, to compensate for the roll and pitch of the ship.

The control and power equipment group is located belowdeck in a compartment usually called the radar room. This room contains the radar consoles used to operate, monitor, and control the radar set. Also located in the radar room are the cabinets containing the power supplies that provide the operating voltages for the various units in the radar set.

Representative Missile Computer

The representative guided missile fire control computer described here is an electromechanical type designed to operate automatically. No operating personnel are needed. It is located in the ship's plotting room, and is used with the radar set described previously.

The computer has three basic ways of operating. It can operate when designation is desired; then, after the radar set has acquired the designated target, the computer aids the radar set in tracking it As soon as the missiles have destroyed the target, the computer shifts to the air-ready method of operation. These different methods of operating are called modes. The various modes of computer operation can be briefly described as follows.

AIR-READY MODE.—In this mode the computer is energized, but is receiving no information. It generates orders only to put the radar set and launcher in predetermined air-ready positions. For example, the air-ready position of the radar set may be at zero° of train and 45° of elevation; the launcher air-ready position may be at 180° of train and zero° of elevation.

DESIGNATION MODE.—The computer goes into this mode of operation when it receives a "director assigned" signal from the director assignment console of the WDE. The computer

directs the radar set to the designated target position so that the radar line of sight will point at the target. It also sends a search program to the radar set. The search program causes the radar beams to move in a preset pattern about the designated target position. The radar searches for the target, and when the target is gated the computer automatically goes into the track mode of operation.

TRACK MODE.—When the radar set acquires the target in range, bearing, and elevation, the track mode starts. The radar set then transmits an on-target signal to the computer. The computer sends signals to the radar set that cause it to drive at a rate that will keep it locked on the target. The computer determines the proper lead angles for the launcher, and transmits these quantities in the form of electrical signals. These signals drive the launcher to the proper aiming position.

Before the missiles are launched, the computer determines and transmits to the missiles quantities that move the missile gyros to their proper positions. The computer also transmits tactical data such as present target position future target position, and missile time to target intercept (time of flight) to the various display consoles of the WDE.

DELIVERY UNITS IN A REPRESENTATIVE WEAPONS SYSTEM

The delivery units of a representative weapon system are the gun and the missile launcher. In this section we will discuss only the missile launcher and the equipments associated with it.

Guided Missile Launching System

The guided missile launcher shown in figure 11-4 is part of a group of equipments that are known collectively as a Guided Missile Launching System. A guided missile launching system has three major components:

1. Guided missile launcher
2. Guided missile launcher feeder
3. Guided missile launching system control

The primary purpose of a guided missile launching system is to stow missiles until needed and then supply them to a launcher for firing. Its secondary function is to remove unfired missiles from the launcher and return them to the missile stowage area.

GUIDED MISSILE LAUNCHER.—Except for Polaris, all Navy missiles that are launched from ships use zero-length launchers. This type has one or two, usually two, launcher arms (or rails). The launcher shown in figure 11-4 is the dual-rail type. It receives and secures two complete missiles—one on each launcher arm. The launcher automatically trains and elevates in response to synchro signals (missile launcher orders) from the fire control computer. Through various devices on the launcher arms, the missiles receive warmup power before launch. Warmup power is used to bring the missile gyros up to speed, and to warm up the vacuum tubes, without taking power from the missile power supplies. Preflight information is also supplied to the weapon through contactors in the launcher arms, and the firing circuit is connected through the launcher to the missile's internal firing circuitry. The launcher can automatically return to a predetermined fixed position in which a new missile can be loaded on the launcher arm, or an unfired missile can be returned to stowage.

LAUNCHER FEEDER.—The purpose of this group of equipments (fig. 11-4) is to stow guided missiles and their boosters in magazines, to remove them from the magazines, and to load them on the launcher arms. There are several types of feeders, but they all have these two purposes.

LAUNCHING SYSTEM CONTROL.—This equipment group includes the panels used to operate the missile launching system. The power panels contain circuit breakers, overload relays, and other electrical components required by the various power drives that control the movement of the launcher, rammer, and ready-service ring. Other panels contain operating controls that are used to start the system and control its operation. These panels normally respond to orders from the WDE. For example, the WDE may send an order to ALERT the missile launching system. An ALERT light on a panel flashes, indicating to the operator that WDE wants the missile launching system's equipment put into operation. Several of the orders transmitted from the

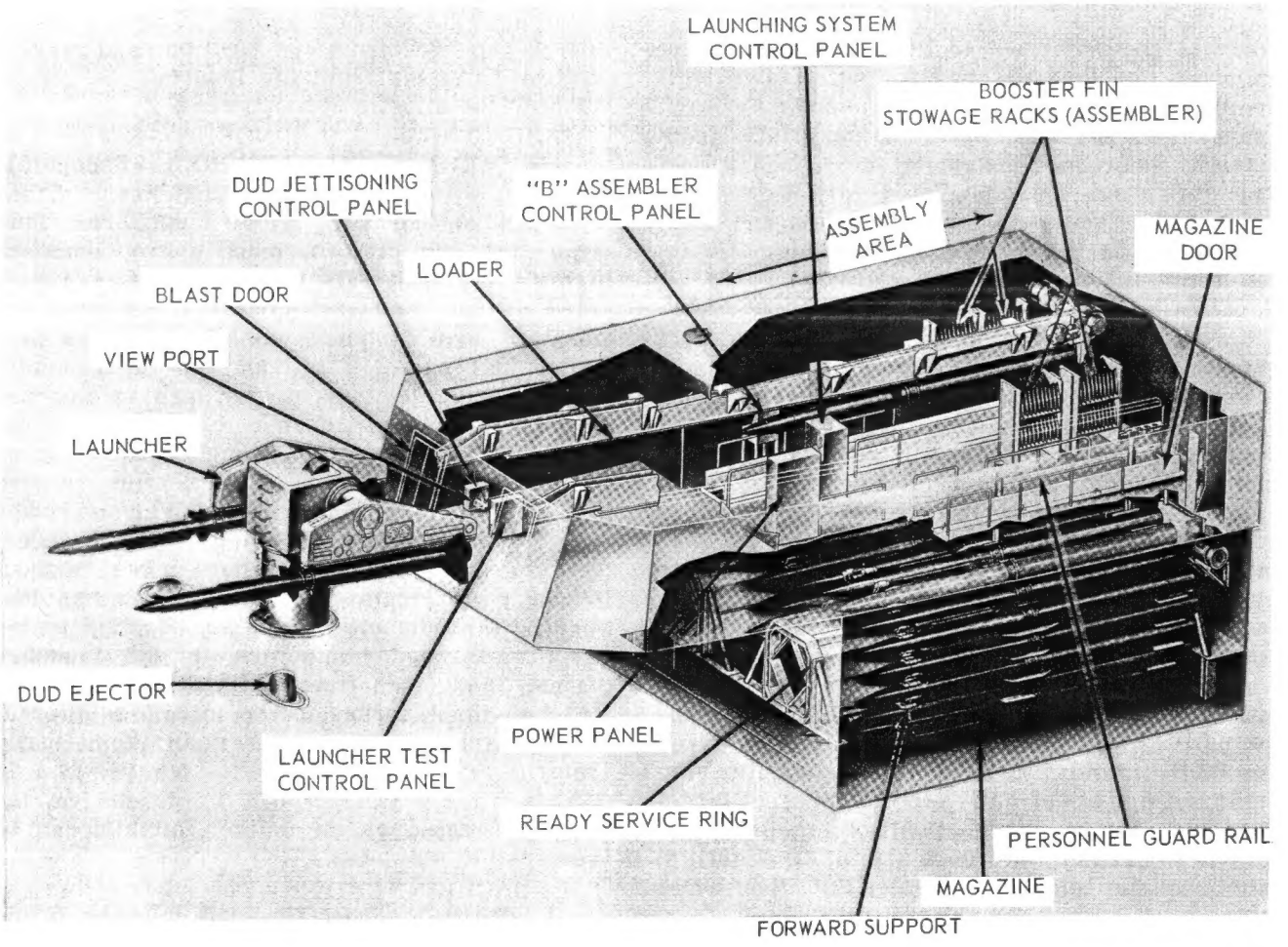

Figure 11-4.—Representative Terrier missile launching system.

WDE to the missile launching system are of interest to the FT.

TYPES OF ORDERS.—The MISSILE SELECT order is transmitted from the WDE to the launching system to indicate the type of missile to be loaded on the launcher. There are several types of Terrier missiles. All of these types may be loaded together in a single magazine. This is called mixed loading. When the launching system has selected the type of missiles called for by the WDE, it sends back a signal indicating that the order has been carried out.

The LOAD ORDER tells the launching system to start loading a missile or missiles. A load order may be "continuous," "single," or "hold." A "continuous" order causes missiles to be continuously supplied to the launcher. This operation is similar to "rapid or continuous fire" in conventional gunnery. The "single" order causes one missile per arm to be loaded on the launcher. The "hold" order holds the launching system in a ready-to-load condition.

When the launching system receives the UNLOAD ORDER, it unloads any missiles that may be left on the launcher arms.

The INTENT-TO-LAUNCH (ITL) is similar to the conventional "commence fire" order in one respect—it is transmitted by closing a firing key. But, while the gun firing circuit is completed almost instantly when the key is closed, there is a slight delay before a

missile firing circuit is completed. This delay is necessary to establish certain operating conditions in the missile, and other equipments in the weapon system. Before the missile can be fired, it must indicate that it is ready to be launched. This indication, "missile-ready-to-fire," is sent through the launching system control circuits back to the WDE. Almost every piece of equipment in the weapon system affects the operation of the firing circuit, either directly or indirectly.

DESTRUCTION UNITS IN A TYPICAL WEAPONS SYSTEM

As we mentioned earlier in this chapter, our typical weapons system is designed to control two weapons, the gun (projectile) and a guided missile. Both of these weapons have already been discussed; therefore these units will not be cover here.

GUNFIRE CONTROL SYSTEM

Here we will compare the functions of the major units in a GFCS with those in a missile fire control system, (MFCS). Since the same basic elements are present in the missile and the gun fire control problem, both types of systems will have the same major units and the primary function of the units will be the same. This is clearly illustrated by the fact that the weapon control system we just discussed can control both missile and gun batteries.

Variations between the problems and the functions of the major units are the result of the differences between the guided missile and the gun projectile. The missile is guided during its flight; hence its control problem continues after launch. On the other hand, once a gun projectile is fired the gun control problem for that round is completed. The missile, having a longer range and higher altitude capability, extends the limits of its problem beyond those of the gun problem; but this fact does not change the basic problem.

We will follow target information through a gun fire control system, starting with the initial detection of a target by the search radar. At each major unit we will point out the principal differences between it and its counterpart in a missile system.

TARGET DESIGNATION SYSTEM

The target designation system (TDS) is the connecting link between the search radar and the GFCS. The function of the search radar is the same as it is on a missile ship. Due to the limitations of the guns, particularly their range limitation, the designation equipment for a gun battery is simpler than the WDE for a missile battery. A single console with a PPI presentation is used to evaluate, track, assign, and designate targets to the GFCSs.

Guns are assigned to a GFCS by a prearranged ship's doctrine. Thus when the TDS assigns a GFCS to a target, the assignment includes the guns. Normal procedure is to commence fire as soon as the target is within effective gun range. The firing circuit is controlled within the GFCS. Thus when the director has acquired the target, the TDS has completed its job with respect to this target and GFCS. DESIGNATION TRANSMITTER, an optical target detector, can transmit target designation directly to the GFCS without going through the TDS.

If more than one FCS is installed, designation can normally be made between the systems. As you know, this method of target designation is called IDD (interdirector designation).

GUN DIRECTOR AND COMPUTER

Gun directors are manned, and normally have both optical and radar equipment to detect, locate, and track a target. The director crew can readily shift from optical to radar tracking, or vice versa. The radar transmits a single target-tracking beam. Another function of gun directors is to furnish a centralized control station and a remote firing station for the battery.

There is little to distinguish between gun and missile computers. Due to the nature of today's air targets, Anti-aircraft (AA) computers are almost fully automatic, with little or no provision for manual operation. Gun computer outputs of train, elevation, fuze, and parallax orders drive the gun to the predicted position of the line of fire. The entire problem of locating the correct line of fire is solved before the projectile is fired.

WEAPONS SYSTEM FUNCTIONING

To provide a brief review of what you have studied so far in this chapter, we list the

principal steps or phases a typical weapons system goes through to accomplish its mission. The mission, of course, is to destroy the enemy or a practice target. The principal steps, in chronological order, are:

1. TARGET DETECTION. Search radars detect targets at long ranges, to allow time for the weapons system to go into action and complete its function.

2. TARGET SELECTION. The weapons direction system selects the targets that appear hostile, and that require missile and/or projectile interception, and inserts them into tracking channels. Target selection and tracking is performed by personnel assigned to the target selection and tracking console—a unit of the weapon direction equipment.

3. SEARCH RADAR TARGET TRACKING. The tracking channels (computing circuits) continuously track selected search radar targets to generate target rate of movement. This data appears as a symbol (letter) on the face of a large cathode-ray tube (scope). When the tracking channel has computed the correct target course, speed, and rate, the symbol on the scope will remain superimposed on the target echo supplied by the search radar. This computed target position and rate data is used for evaluation of the tactical situation presented to the ship, and for transmission to other units in the WDS—especially the director assignment console. Each target that is being tracked is assigned a different symbol to prevent confusion.

4. EVALUATION. The weapon system evaluates the threat of various targets, decides which should be engaged by guns and which by missiles, and decides which targets should be given priority. The evaluation is performed by personnel, but they are aided in this process by the displayed information on the various consoles in the WDE and CIC.

5. DIRECTOR ASSIGNMENT. A radar set is assigned to the target having the highest priority. When a radar set is assigned, this implies that a fire control system has been included in the assignment.

6. ACQUISITION. The assigned radar set (fire control system) gets on the target.

7. TRACKING. The fire control radar tracks the target to provide precise target position and rate data. The computer associated with the tracking radar operates on the data from the radar set to provide the solution to the fire control problem. The computer answers are supplied to the guns and launcher as synchro signals to position these units in train and elevation.

8. REEVALUATION AND WEAPON ASSIGNMENT. The target that is engaged by the fire control system is reevaluated with respect to the tactical situation (this may have changed), availability of the launcher or gun, and the range limitations of the weapons.

9. LOADING. Missiles are loaded on the launcher, and the guns are prepared for firing.

10. LAUNCHING AND FIRING. The missiles are launched at the proper time and in the proper direction. The guns are loaded and fired.

11. MISSILE GUIDANCE. The fire control radar guides each missile to the target being tracked. Gun projectiles, of course, receive no guidance.

12. TERMINAL PHASE. When a missile or projectile approaches to within lethal range of the target, a VT (variable type) or other type fuse detonates its destructive charges. This is the "moment of truth" for the weapons system.

SUMMARY

A weapons control system consists of a combination of a weapon (or multiple weapons) and the equipment used to bring their destructive power against an enemy. The system includes:

1. Units that detect, locate, and identify the target.
   a. Search radars
   b. Optical target designation transmitter
   c. IFF radar
2. Units that direct or aim a delivery unit.
   a. Gun and guided missile radar and directors.
   b. Computer devices (rangekeepers and computers)
   c. Display units (electronic, electromechanical, or optical devices)
   d. Reference devices (stable elements) to establish reference planes and lines to stabilize lines of fire and lines of sight
3. Units that deliver or initiate delivery of the weapon to the target.
   a. Guns
   b. Missile launchers
4. Units that will destroy the target when in contact with it or near it.
   a. Shells
   b. Missiles